

Material Production, Mix Design & Pavement Design Effects on Moisture Damage

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Moisture Sensitivity Seminar

La Jolla, California

February 11 to 13, 2003

Raveling



Fatigue Cracking



Rutting



Potholes



Moisture Damage

- Material production effects
- Mixture design effects
- Pavement design effects

Materials Production Effects on Moisture Damage

- Hot mix asphalt is a combination of asphalt binder and aggregate.
- The physical bonding of these two materials drives moisture damage.
- We must understand the basics of these materials to understand moisture damage

Materials Production Effects on Moisture Damage

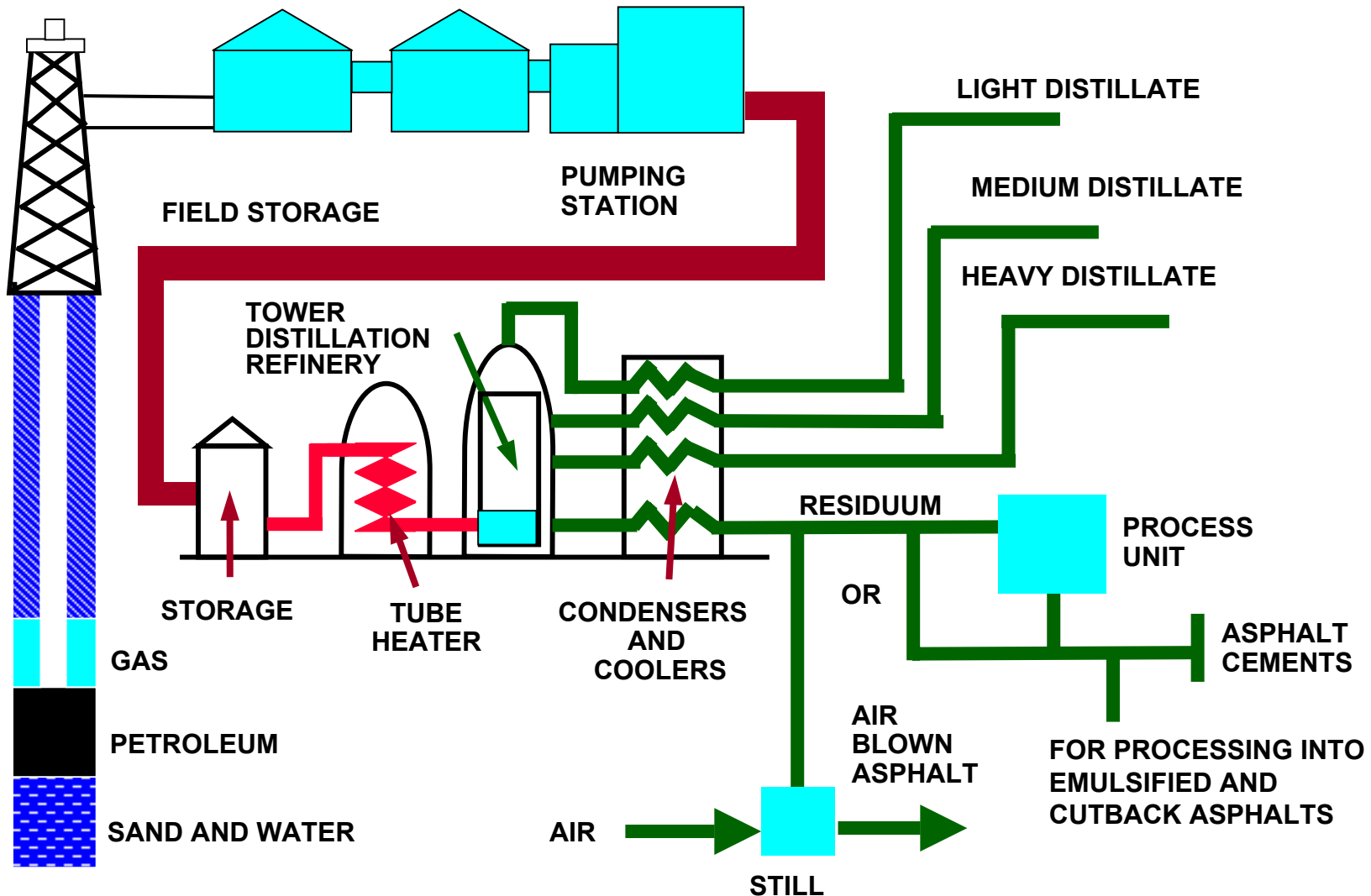
- Asphalt binder properties are driven by the crude source, the refining process, and any additives used.



Asphalt Refining

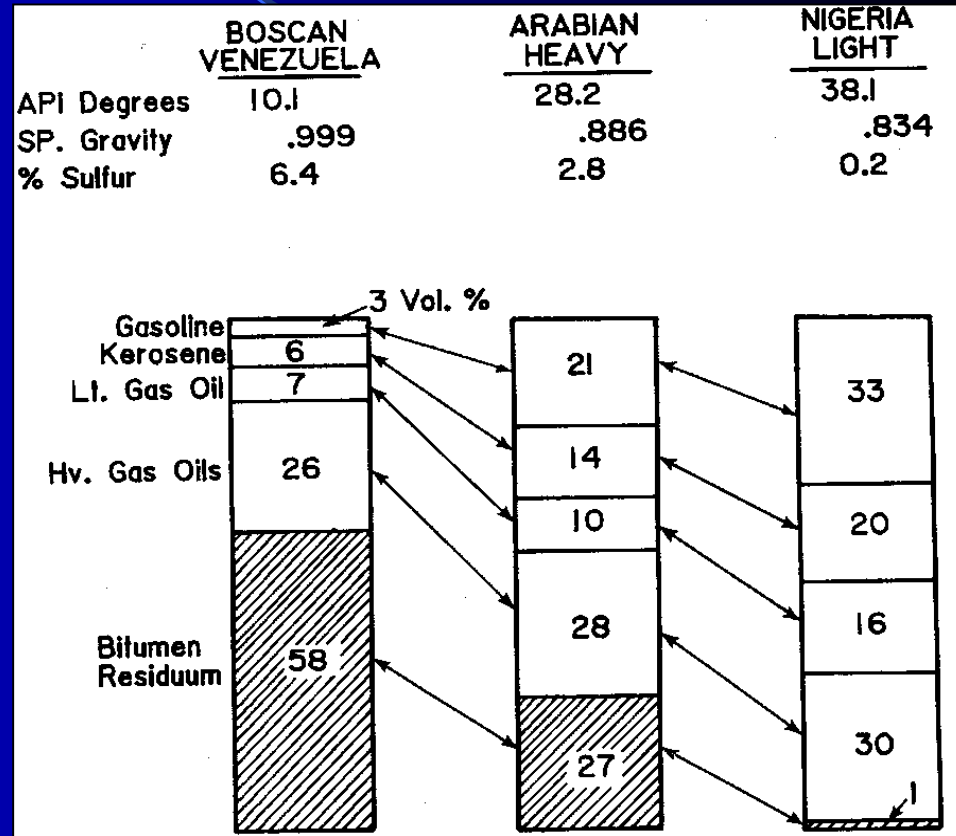


Refinery Operation



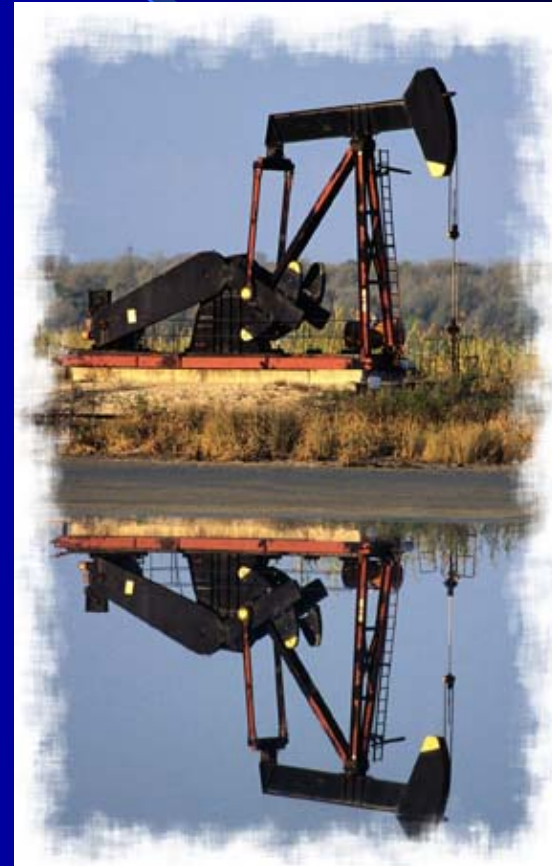
Crude Oil

- Different crude oils will produce different asphalt binders with different properties.



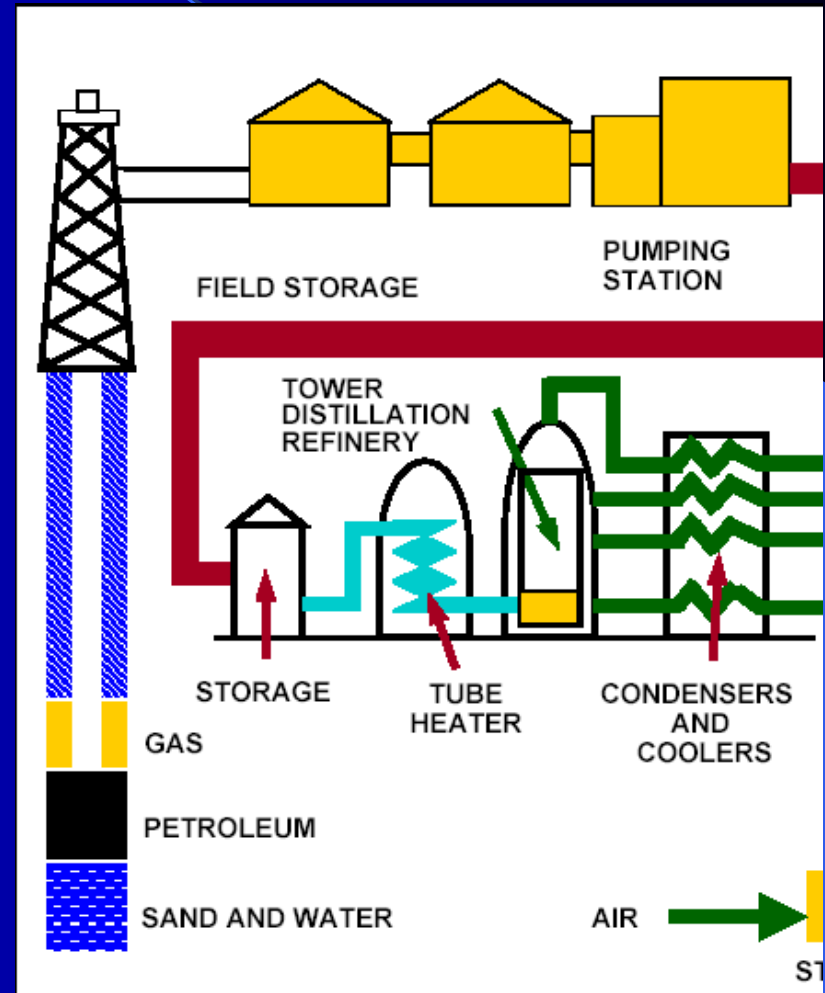
Crude Oil Refining

- Crude oil is pumped from under the ground. The crude will typically contain water and salts in its unrefined state.



Crude Oil Refining

- Water and salts should be removed from the oil before it is processed through the refinery.
- This is done in settling tanks before distillation.



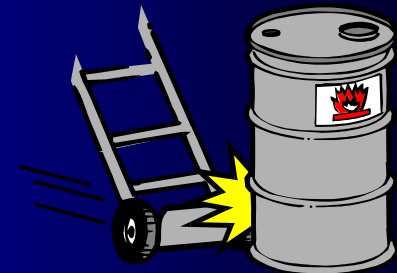
Crude Oil Refining

- Most crude oil is somewhat acid. This is particularly true for crude which produces higher percentages of asphalt.
- Additives are used to reduce the acidity.

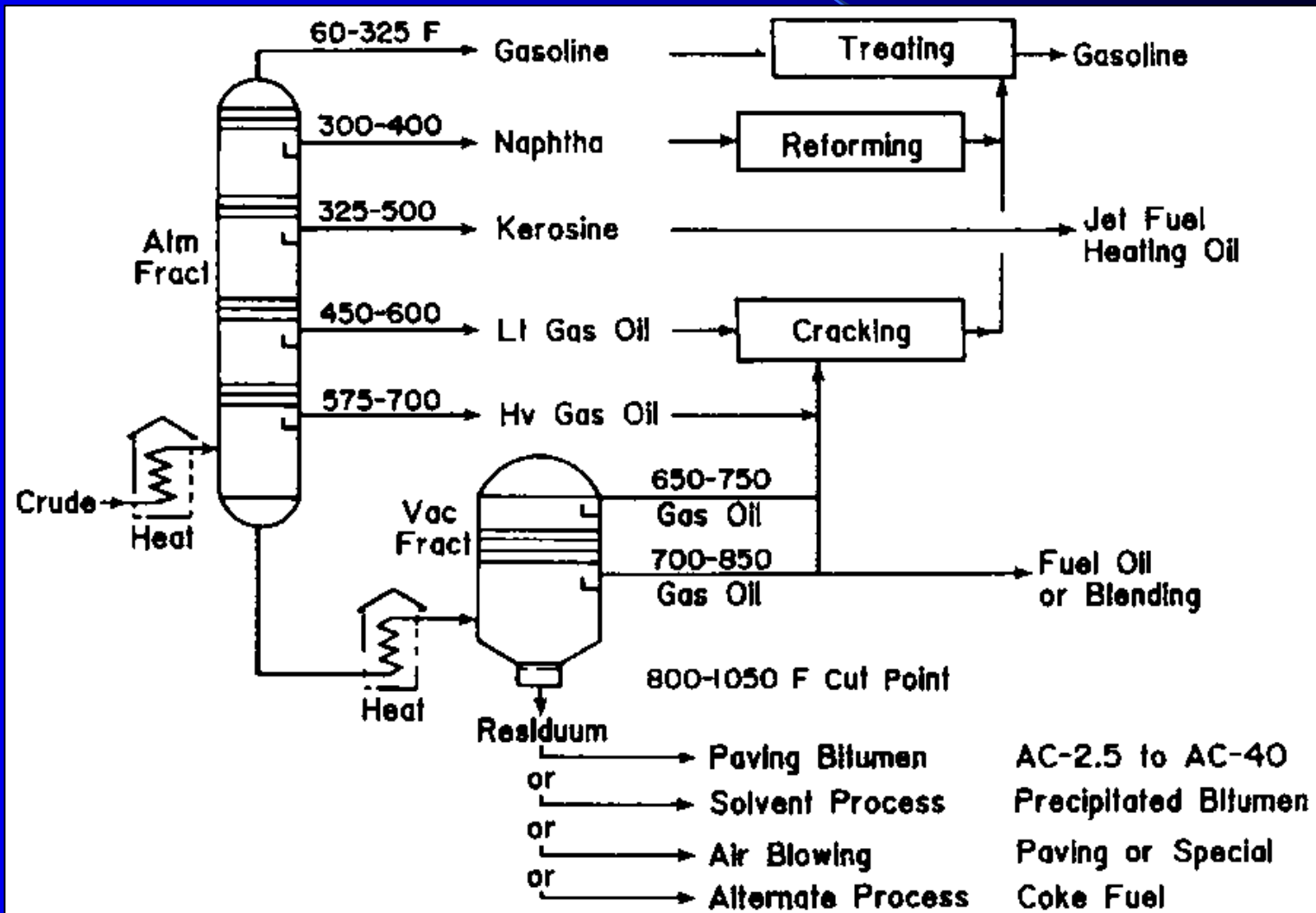


Crude Oil Refining

- Crude oil pretreatment to reduce acids
 - Steam and lime are added to the crude to reduce acid and then removed before refining.
 - Caustics sodas have also been used. These can cause many problems if not completely removed from the crude before refining



Crude Oil Refining

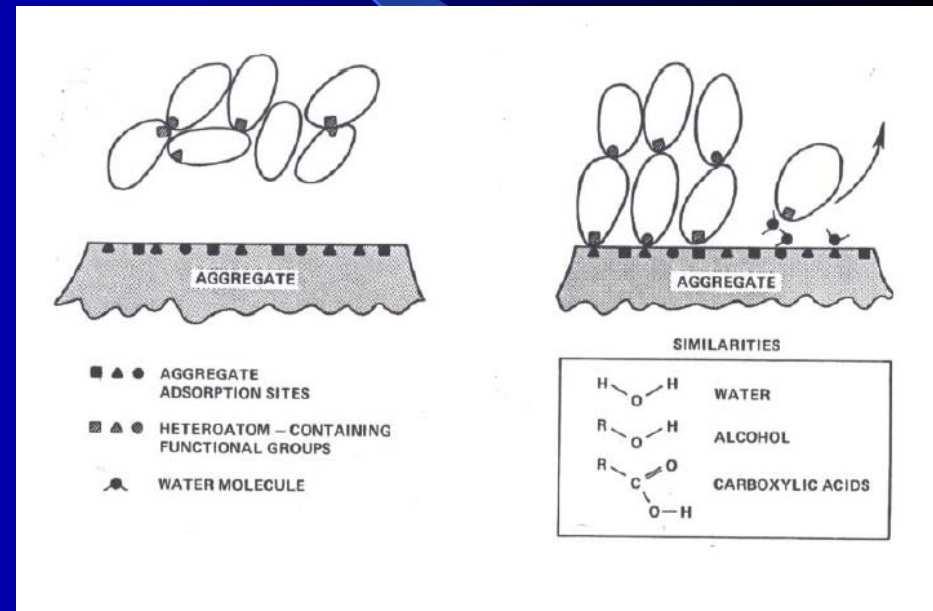


Acids in Asphalt Binders

- *Carboxylic acids (RCOOH) and sulfoxides are present in asphalt binders.*
- *They will increase with aging.*
- *The amount varies based on crude oil and treatment.*

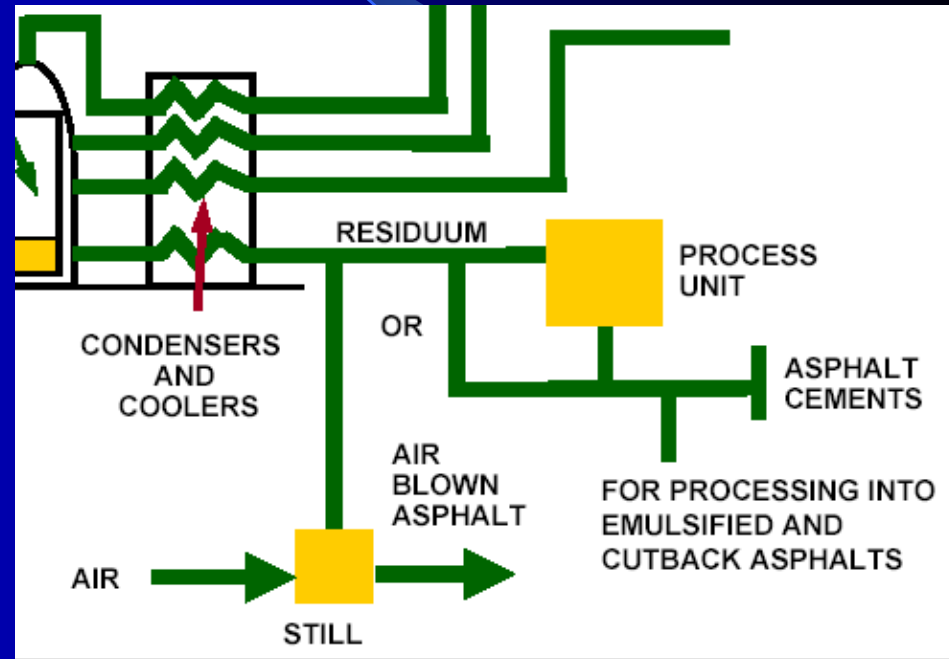
Acids in Asphalt Binders

- Carboxylic Acids and sulfoxides will attach to aggregate surfaces before other compounds in the binder.
- These materials are also easily displaced by water.



Asphalt binder Modification

- Oxidation or air blowing is a typical modification process for binders.
- Oxidation will increase carboxylic acids. The amount varies based on crude and amount of oxidation



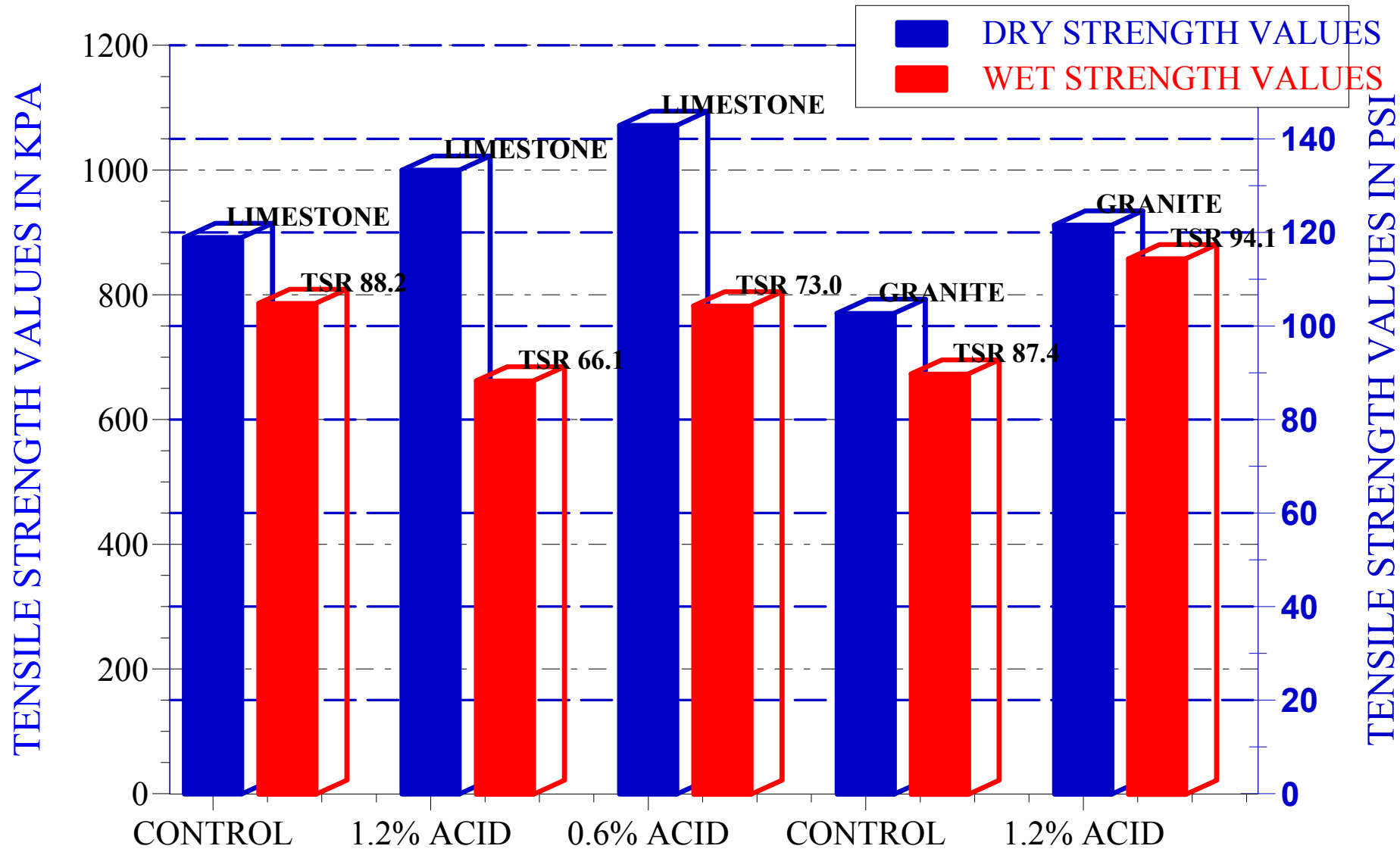
Asphalt Binder Modification

- Many different materials are used to modify asphalt binders. These modifiers all have different effects on moisture sensitivity.
- The modifiers include: polymers, acids, caustics, and fillers.

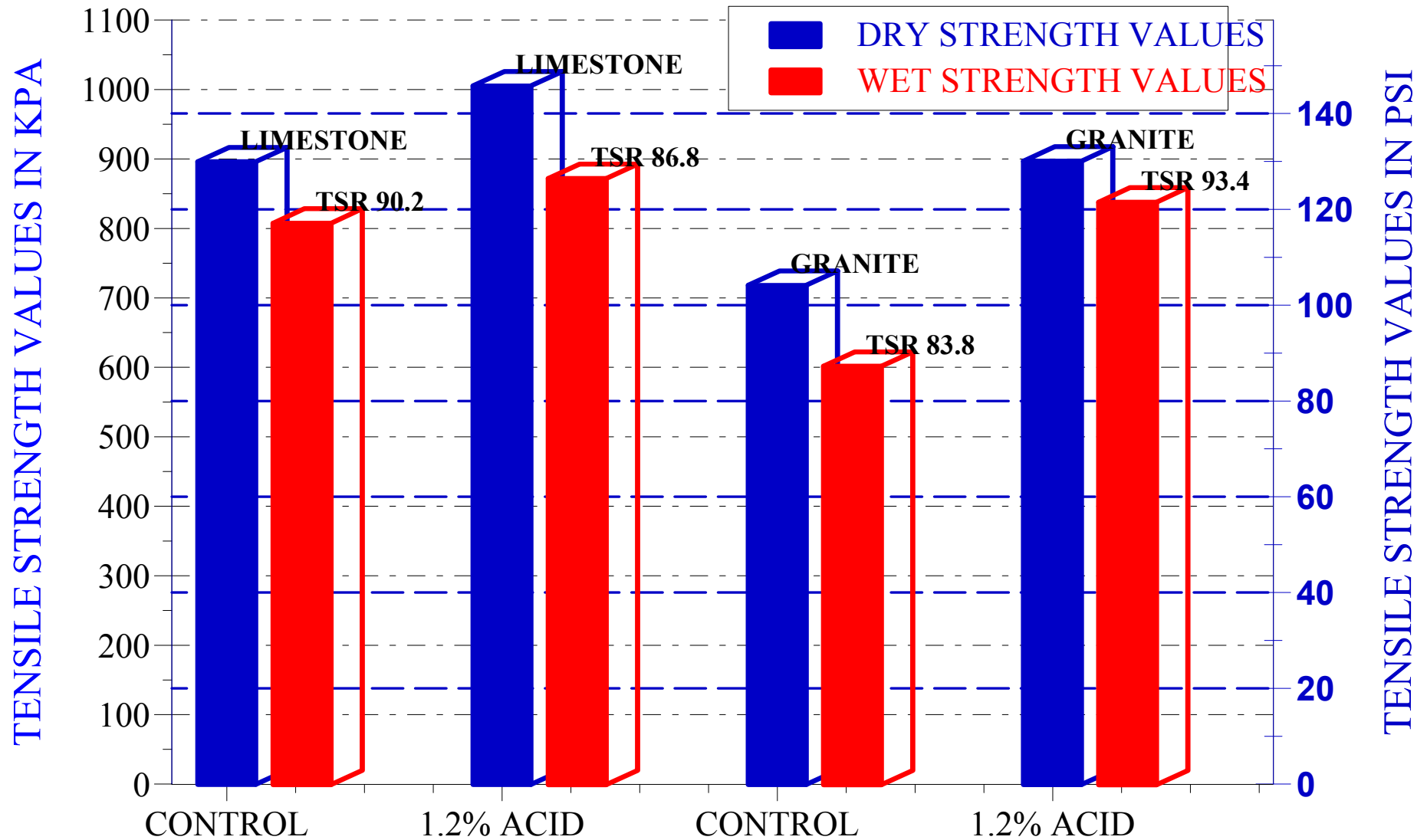
Asphalt Binder Modification

- Polymer modification will typically improve resistance to moisture sensitivity due to increased stiffness.
- Acids may improve but can reduce resistance to moisture damage.
- Caustic modification creates water soluble salts in the binder that will emulsify the binder in the presence of water. They also cause corrosion problems.

**TENSILE STRENGTH TEST RESULTS FOR SOURCE C 67-22
AND SOURCE C 67-22 + 1.2% OR 0.6% POLYPHOSPHORIC
ACID USING LIMESTONE AND GRANITE MIXES**



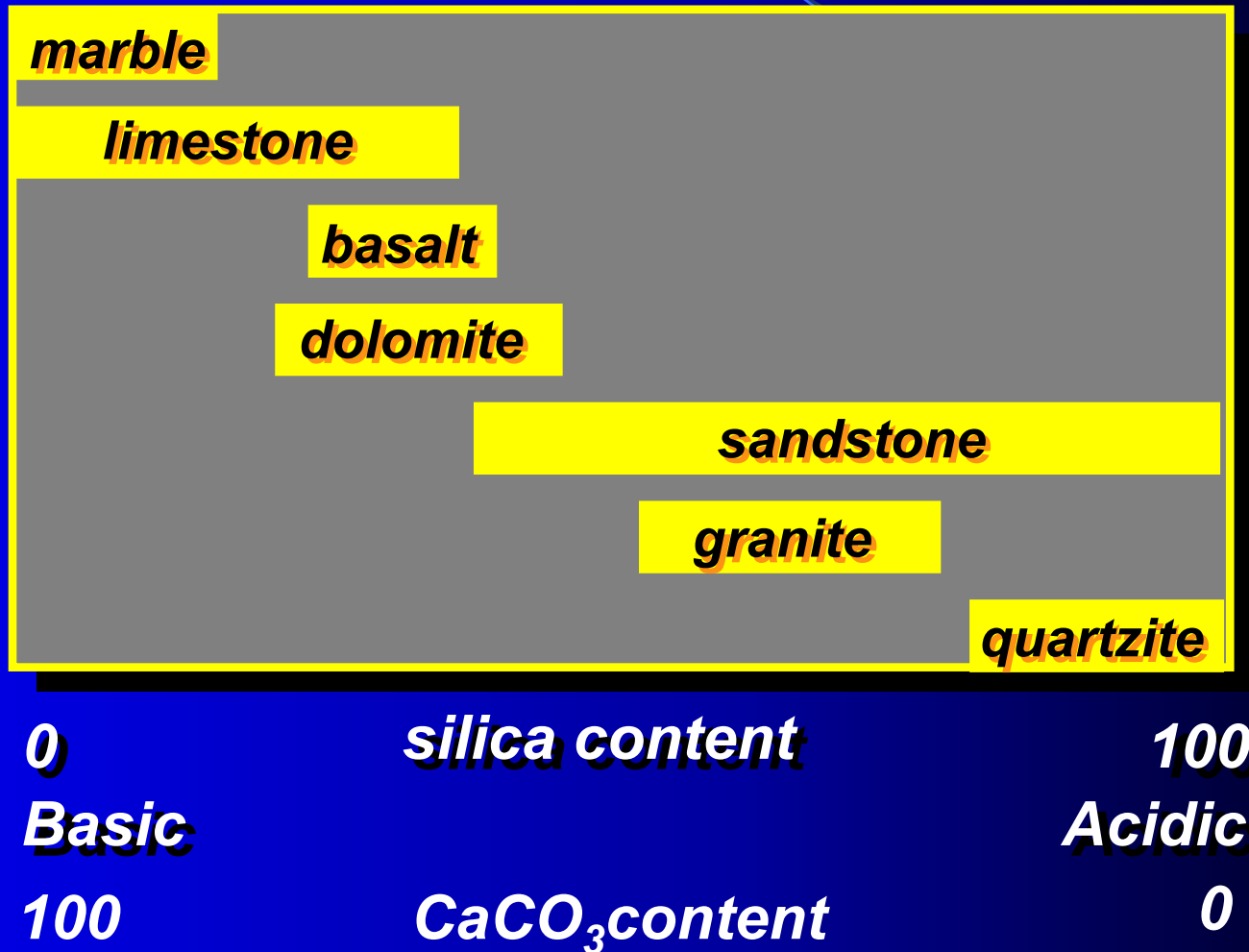
TENSILE STRENGTH TEST RESULTS FOR SOURCE B 64-22 AND SOURCE B 64-22 + 1.2% POLYPHOSPHORIC ACID USING LIMESTONE AND GRANITE MIXES



Aggregate Production

- Aggregates have a complicated chemical make-up.
- Acid base bonding is the primary adhesion between asphalt and aggregate.

Chemical Nature of Aggregates



Chemical composition of Aggregate

- Aggregates are typically silicone or calcium based.

Sample	RA Granite	RB Granite	RC Limestone	RD Limestone
SiO ₂	73.4	56.2	6.49	16.4
Al ₂ O ₃	13.4	19.8	1.23	2.28
Fe ₂ O ₃	2.24	6.49	0.78	0.80
MgO	0.49	2.60	2.52	5.29
CaO	1.24	8.87	48.9	39.1
Na ₂ O	3.41	3.04	0.24	0.16
K ₂ O	4.92	0.44	0.22	1.16
TiO ₂	0.22	0.51	0.03	0.06
P ₂ O ₅	<0.05	0.06	<0.05	<0.05
MnO ₂	0.05	0.12	<0.02	<0.02
LOI	0.22	1.98	40.3	35.0
Total	99.59	100.11	100.71	100.25

Aggregate Production

- Clay in the aggregate can cause problems with stripping.
- The clay swells and will emulsify the binder.



Aggregate Production

- Dirty aggregate can reduce adhesion of the binder.



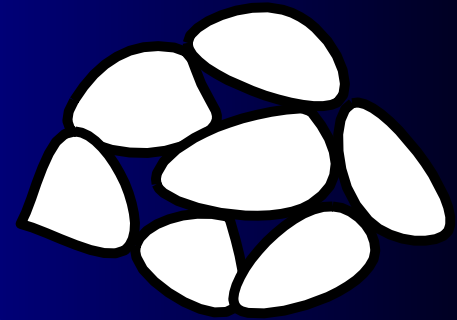
Mixture Design & Moisture Damage

- The actual mixture design along with the proper selection of components can make a mix perform or fail.

Types of Gradations

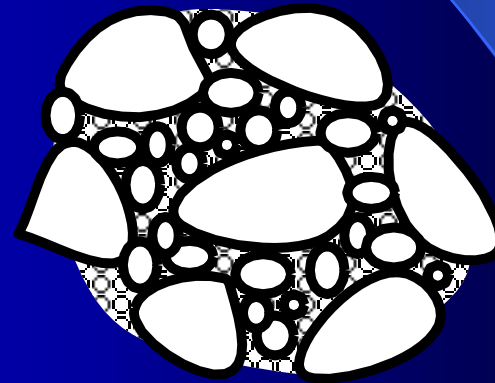
* Uniformly graded

- Few points of contact
- Poor interlock (shape dependent)
- High permeability



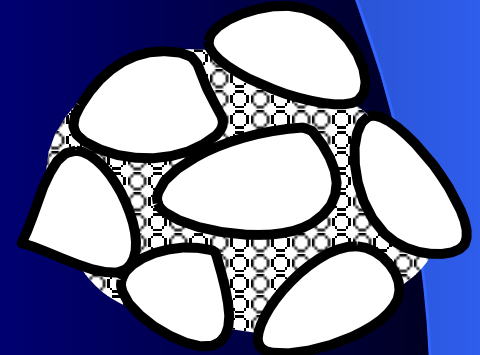
* Well graded

- Good interlock
- Low permeability



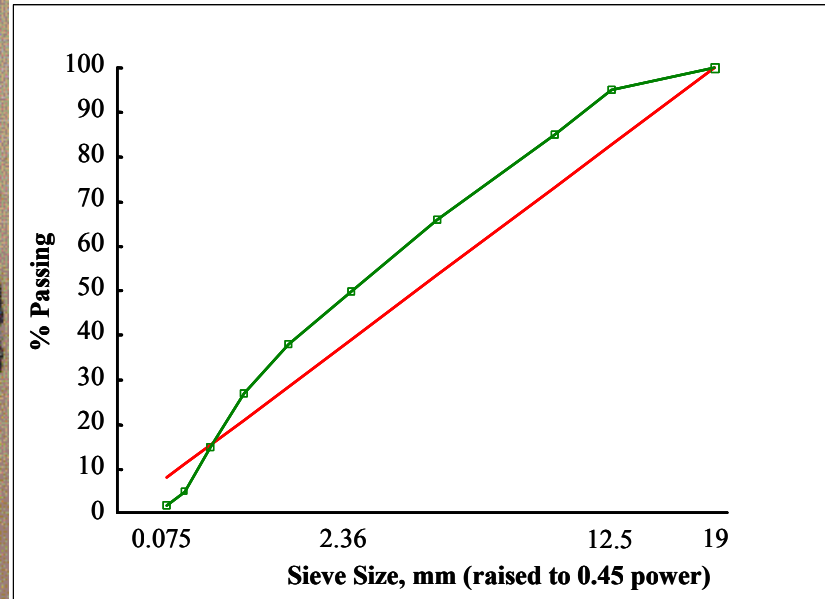
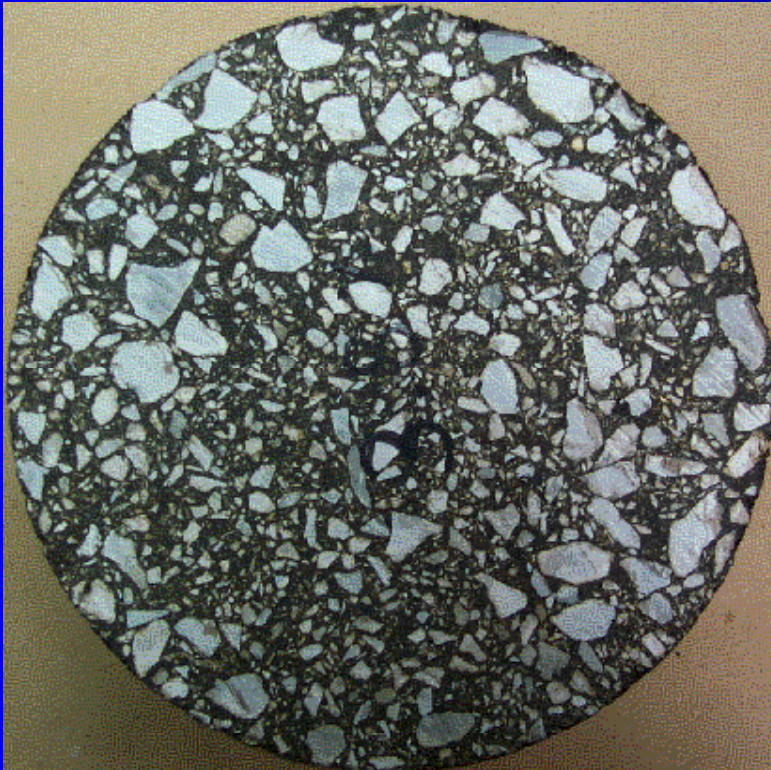
* Gap graded

- Only limited sizes
- Good interlock
- Low permeability



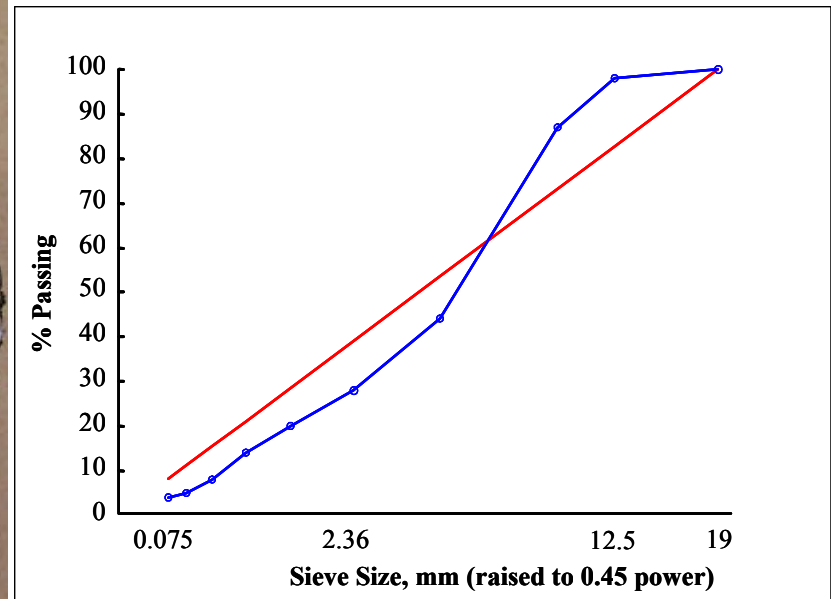
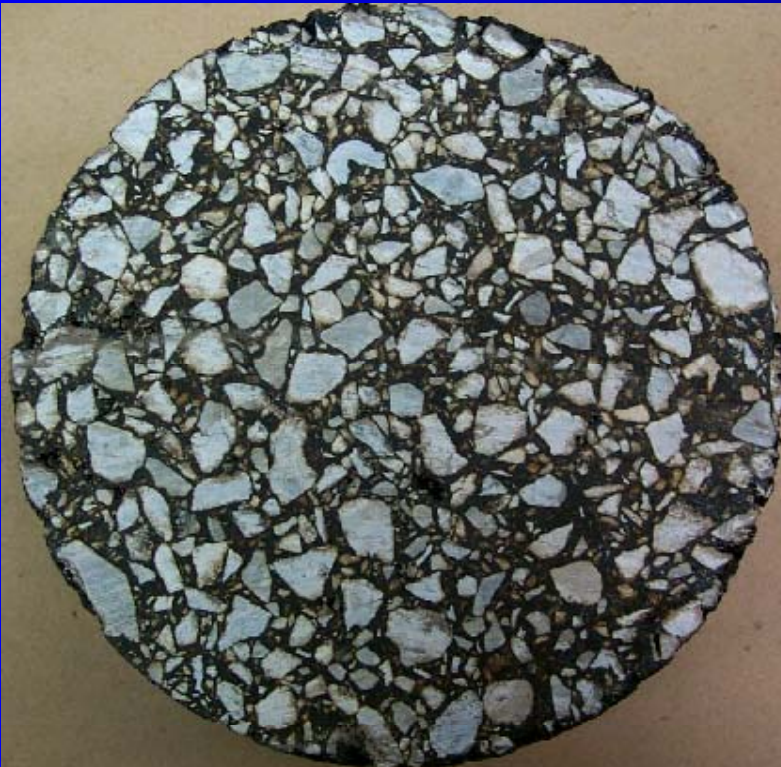
Dense Graded Mixes

Dense Graded Fine Superpave



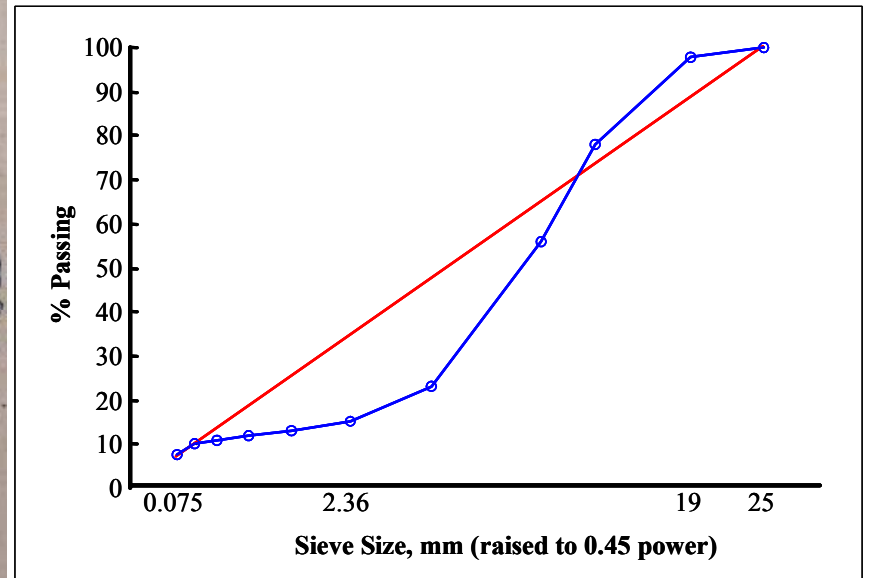
Course Graded Mixes

Dense Graded Course Superpave



Gap Graded Mixes

SMA's



Mix Design & Moisture Damage

- Excess dust in the mix can cause stripping.
 - This is related to the fine to asphalt ratio.
 - High fine with low asphalt binder can mean stripping.
- High voids in the mix can lead to stripping

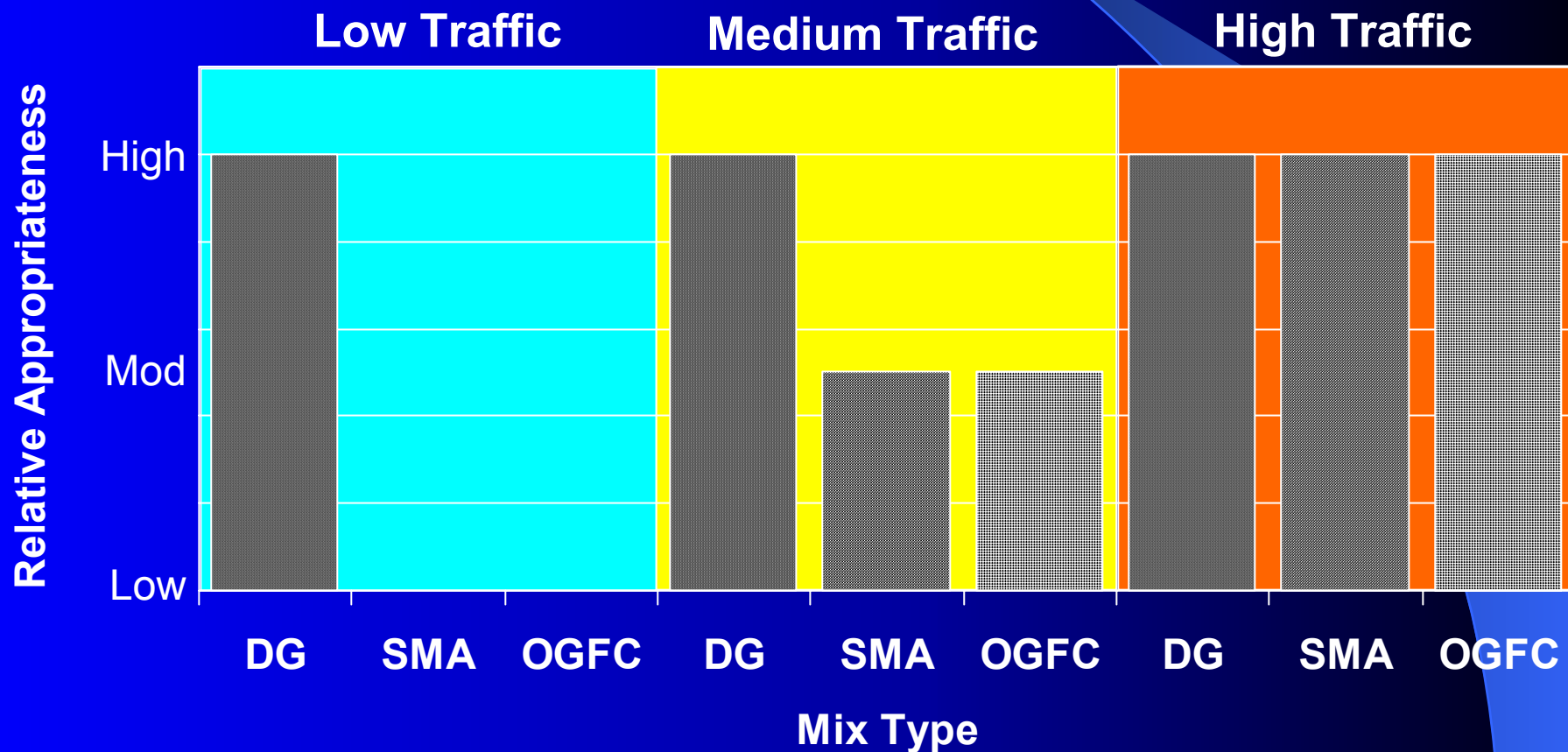
Pavement Design & Moisture Damage

- The design of the pavement structure may have the greatest effect on moisture damage.
 - Lift thickness and compaction
 - Entrapment of water in layers.



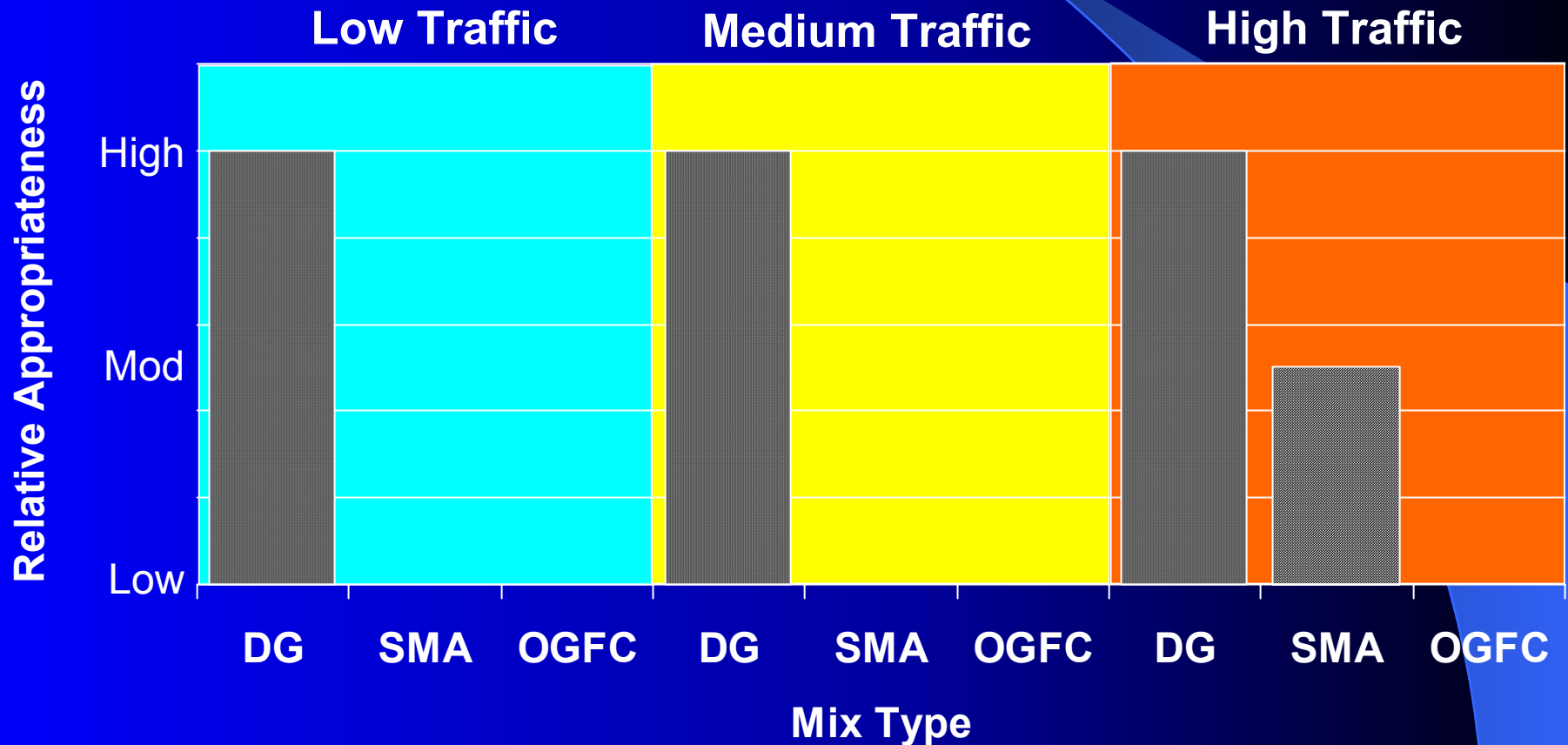
Recommended General Mix Types

Surface Courses





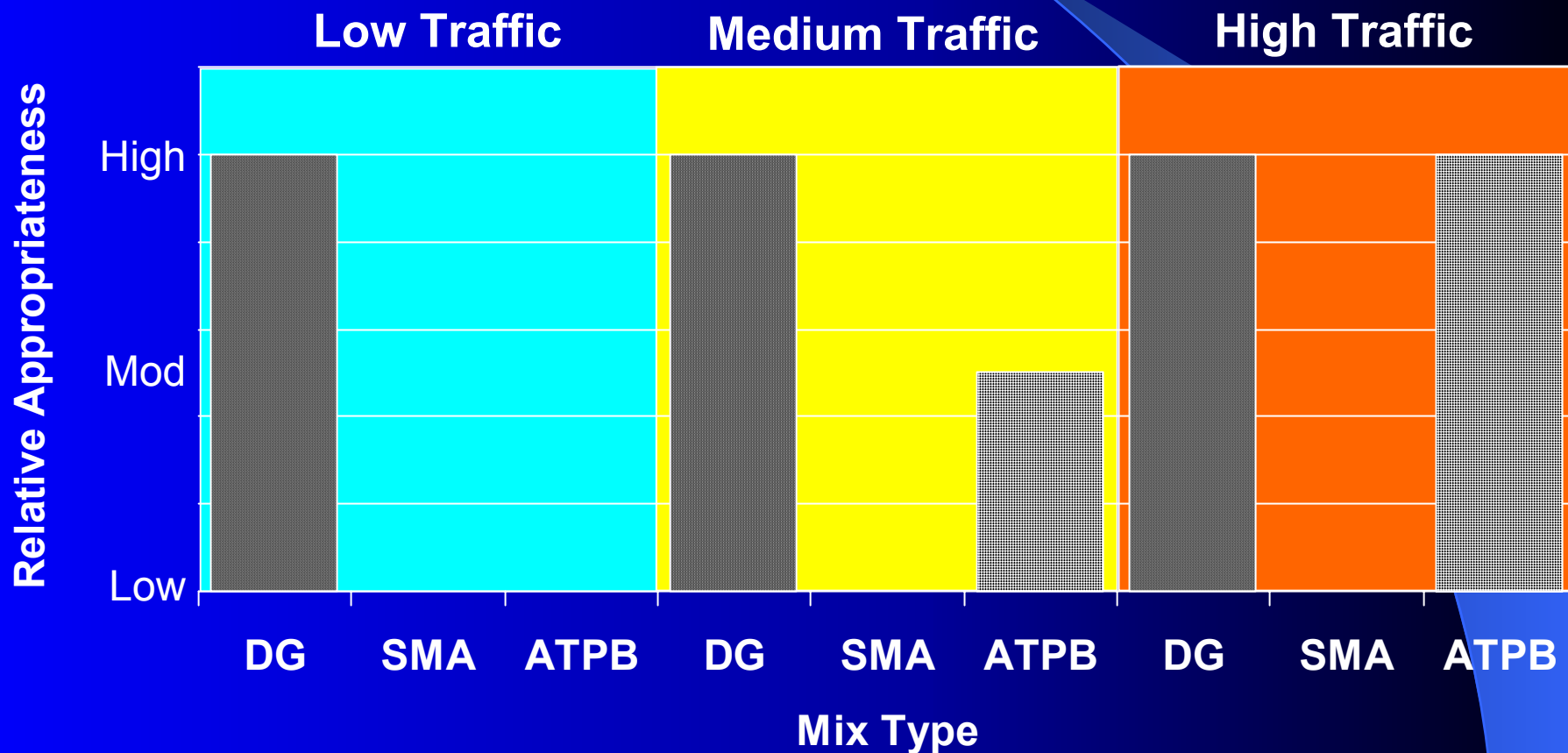
Recommended General Mix Types Intermediate Courses





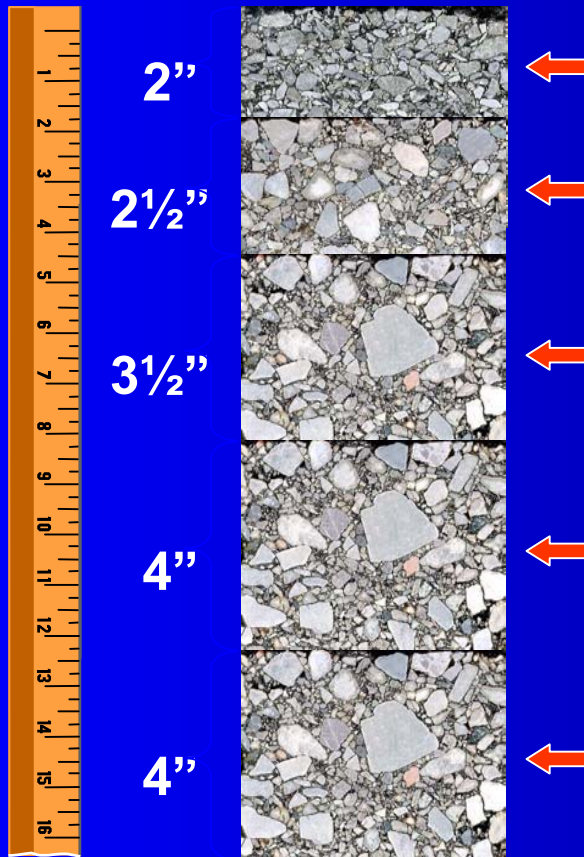
Recommended General Mix Types

Base Courses



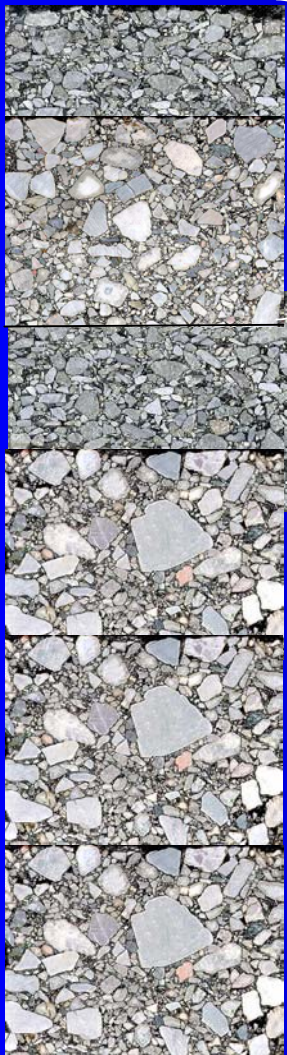
M i x	L i f t T h i c k n e s s (i n c h e s)		
	M i n	P r e f	M a x
4 . 7 5	0 . 5	0 . 7 5	0 . 7 5
9 . 5	1 . 0	1 . 5	2 . 0
1 2 . 5	1 . 5	2 . 0	2 . 5
1 9 . 0	2 . 0	2 . 5	3 . 5
2 5 . 0	3 . 0	3 . 5	4 . 0
3 7 . 5	4 . 0	4 . 5	5 . 0

Mix Size



Lift thickness and aggregate size are critical to getting proper compaction to reduce permeability.

Pavement Design & Moisture Damage



New overlay

Old OGFC

Don't trap moisture in lower layer with new surfaces. This is also true with surface seals and micro surfacing. Drainage is critical.

Material Production, Mix Design & Pavement Design Effects on Moisture Damage

- **Conclusions**

- Moisture damage is effected by components, mix design, and pavement design.
- There are many aspects of the binder that can cause stripping. Different additives and residual material left in the binder can cause stripping. The binder should be tested with all additives included.

Material Production, Mix Design & Pavement Design Effects on Moisture Damage

- **Conclusions continued**
 - Binder Aggregate mixtures tell the real story and all testing should be done on production aggs and binder.
 - Proper mix selection tied with appropriate lift thickness aids compaction to reduce permeability.
 - The right layer in the right place can reduce problems.

Thank you

Questions?